

# The Effect of Interaction and Design Participation on Teenagers' Attitudes towards Social Robots

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**Abstract**—Understanding people's attitudes towards robots and how those attitudes are affected by exposure to robots is essential to the effective design and development of social robots. Although researchers have been studying attitudes towards robots among adults and even children for more than a decade, little has been explored assessing attitudes among teens—a highly vulnerable population that presents unique opportunities and challenges for social robots. Our work aims to close this gap. In this paper we present findings from several participatory robot interaction and design sessions with 136 teenagers who completed a modified version of the Negative Attitudes Towards Robots Scale (NARS) before participation in a robot interaction. Our data reveal that most teens are 1) highly optimistic about the helpfulness of robots, 2) do not feel nervous talking with a robot, but also 3) do not trust a robot with their data. Ninety teens also completed a post-interaction survey and reported a significant change in the emotional attitudes subscale of the NARS. We discuss the implications of our findings on the design of social robots for teens.

## I. INTRODUCTION

Understanding the attitudes towards robots of different populations is critical in the design of social robots that will be accepted and adopted by those populations. Attitudes affect decision making [3] especially decisions related to the adoption and acceptance of new technologies [19]. Attitudes towards robots have even been shown to predict behavior during human-robot interaction (HRI) [28]. According to [13], from a design perspective, it is imperative to better understand "which aspects of robots evoke what type of emotions and how this influences the overall evaluation of robots." Although attitudes have historically been considered a stable trait in humans, they are known to be affected by culture and social influences [33]. Nomura, Kanda, & Suzuki [27] suggested that attitudes may be also influenced by personal experiences, such as interacting with robots.

Prior explorations of attitudes towards robots have focused primarily on adults [30], [42] and even children [7], [41], ignoring teens as a potential target user group. However, we think teenagers present an important opportunity to use social robots for addressing challenges experienced by this user group. This is because (1) teens are growing up in a digital world [17] and are likely to have future relationships with robots, (2) teens are a highly vulnerable population, especially due to extreme stress [2] which leads to depression

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Fig. 1: We compared 90 teenagers' attitudes towards social robots *before* and *after* participating in a variety of interaction studies or design activities in their own high-school setting.

[24], [39]. Given the digital world of teens and their vulnerability to mental health issues, therapeutic social robots could play an essential role in improving their health. It has been proposed that mental health technologies, such as robots, could be leveraged to support adolescent mental health in particular [18].

When it comes to technology design, it is important to recognize that teens are not children or adults [15]. We cannot assume findings from adult and child populations generalize to teens. User characteristics, including age, directly impact the population's abilities, attitudes, behaviors and willingness to use new technologies [21]. Therefore, investigating teen's attitudes towards robots is essential to empirically support further design and development of social robots to aid teen mental health.

In this paper we aim to close the gap on what is known about teenagers' attitudes towards robots and how this attitude changes with exposure to robots. To that end we compared 90 teenagers attitudes towards social robots, measured with a slightly modified Negative Attitudes Towards Robots Scale (NARS) [29], before and after participating in different participatory robot interactions and design activities in their own high-school setting. We describe these studies and present our quantitative findings, along with qualitative observations that support these findings.

## II. RELATED WORK

There have been mixed results in terms of attitudes towards robots in the reviewed literature, particularly across age groups. Work done with older adults [35], [37] shows that the mental models and preconceptions of robots before any interaction occurs affects the interaction itself. In both studies, there was an increase in the positive attitudes after the interaction took place. The authors suggest that taking into account pre-interaction mental models can help with robot acceptance, and suggest using drawings of robots to assess any initial anxiety. Also in adults, engagement with the design of robot prototypes has been shown to positively affect attitudes and decrease anxiety towards robots [31].

Attitudes have also been explored in young children. Studies done with children, ages between 6 and 9, [10] found an increase in children's positive moods after interacting with a socially assistive robot; the authors did not find, however, significant changes in levels of anxiety or in negative moods. However, work done with young adults [13] reported higher anxiety levels after an interaction with a conversation robot had taken place.

Although attitudes have not been explored, how teens perceive robots has been researched lightly. Agatolio et al [1] found a positive effect in Italian 6th and 7th grade students who had self-reported low levels of self-efficacy. A different study in Sweden, surveyed teenagers about the role of robots in educational contexts [34]. Teens showed positive attitude towards interacting with a humanoid robot that showed emotions but were against the robot storing any information about their interaction. In Taiwan, Liu [23] surveyed 4th, 5th and 6th graders about educational robots and learning robotics, and found that early adolescents perceived educational robots and learning of robotics as a plaything (they want a companion), as a source of employment, and as a way to high technology.

As these results may suggest, there is no systematic way to address attitudes towards robots currently. From the reviewed literature, NARS [29] is one of the most common methods to assess attitudes towards robots [3], [13], [38]. However, there are also: Robot Attitude Scale (RAS), Attitudes towards Social Robots scale (ASOR-5) [11], and Abilita e motivazione allo studio (AMOS) [1], among many others.

There is also a limited amount on information about the teenager age range. From a literature review paper [25] on social robots supporting children under medical treatment, only one study out of the ten analyzed included teenagers (age above 12). That single study [26] was done using the Paro robot [8] in a psychology ward in Japan. They obtained mixed results looking at levels of relaxation, communication skills, impulsive behavior, and anxiety; some teens liked the robot, some dislike its features and even feared it.

## III. PROJECT EMAR OVERVIEW

The work presented in this paper is part of a larger effort called Project EMAR, which stands for Ecological Momentary Assessment Robot. The overarching goal of Project EMAR is to measure and address stress in teenagers.

Our research is motivated by recent trends in teenagers' mental health. Teens are now the most stressed generation, with 27% percent of US teens reporting very high levels of daily stress, and 31% reporting feeling overwhelmed as a result of stress [2]. Increased stress has been shown to cause both mental and physical illness [24] and negatively impact cognitive function affecting learning [40]. Stress negatively affects teens at school. 83% percent of teens report that school is a significant source of stress, and 34% predict that the next school year will be even more stressful than the last [2]. Many schools lack the resources (time and personnel) to address the mental health needs of teens [14].

To address these challenges, Project EMAR aims to develop a robot for teens that will be stationed at schools to get more accurate momentary data about teen stress and provide interventions. We take a user-centered design approach, involving teens in all design decisions. In the last three years our research team has conducted a number of exploratory high school visits, a social robot design challenge with 7 participating high schools [6], and several participatory design and interaction studies bringing robots to high schools [4], [5], [32].

In the past year, our focus has turned towards interaction design for a number of "applications" that will be available on EMAR robots to help teens better cope with stress while they are at school. As a result, the last few field studies we conducted involved a variety of activities to design and evaluate interactions on a robot. As part of this effort we measured teenagers' attitudes towards robots, before and after they participated in our studies. In this paper, we report findings from those measurements across different studies and different sites.

## IV. METHODS

Our work involves capturing teenagers' attitudes towards social robots before and after they participate in a robot interaction design activity at their high school. In the following we detail the participants and recruitment process, the unique in-the-wild school setting, the questionnaire we used to measure teenager attitudes towards robots, and the different types of design activities teens participated in between two measurements.

### A. Participants

Before starting our studies, we obtained our university's internal review board approval, as well as a school district research approval. We then reached out to local area high schools (administrators and teachers) and students in STEM related clubs. Five urban high schools from the Seattle area agreed to participate. Our research team worked to meet the scheduling needs of the school and therefore conducted the studies during classes or after school. Once a school agreed to participate, we obtained parental approval for involved students through school administrations, prior to our visit.

### B. Ethic of Participation

Teens who had parental permission were eligible to participate in the study. Teens and parents were also given a choice

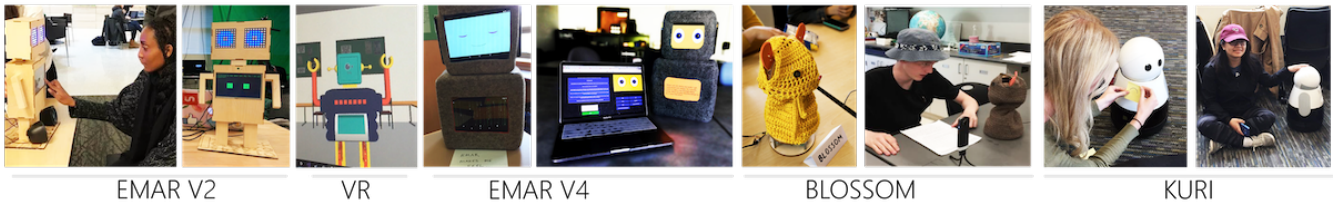


Fig. 2: Array of social robots that teens interacted with as part of design activities.

about the use of media in the study and could opt out of any photographs and/or the use of photos and videos for social media. Only teens who were consented and with parental permission for social media have images shown here. Teens were informed that they could disengage at any time from the study, and change their mind regarding social media and photographs.

### C. Setting

Studies took place in a large classroom or a common area (breakout room) in the high school. A teacher was present at all times. Depending upon the number of participants, a range of 3 to 12 project team members helped run the study and administered the questionnaires (Figure 1).

### D. Questionnaires

1) *Demographics*: Demographic questions asked for age, grade, and self-reported gender and ethnicity. No identity information was gathered.

2) *Teen Attitudes Towards Robots*: To capture teenager's attitudes, we used a slightly modified version of the Negative Attitudes towards Robots Scale (NARS). NARS has been used in many experiments to evaluate participant attitudes towards many kind of robots (Section II). It consists of three subscales:

- S1** Negative Attitude towards Situations and Interaction with Robots (6 items)
- S2** Negative Attitude towards Social Influence of Robots (5 items)
- S3** Negative Attitude towards Emotions in Interaction with Robots (3 items)

To make NARS appropriate for teenagers we removed questions that were written from an adult's perspective, such as "I am afraid that robots may negatively influence children's mind (S2) and "I feel anxiety when I imagine that I may be employed and assigned to a workplace where robots should be used" (S1). We retained all of S3 as we were most interested in teen's attitudes related to emotions in robot interactions. We also added three new items related sharing data with robots and the general role of robots (Q8–Q10 in Table I). We used the standard NARS 5-point likert scale from Strongly Disagree (1) to Strongly Agree (5) for all items.

3) *Perceived Stress*: As we are exploring the design of stress-reducing robot interactions, we were interested to gather stress data from each participant using the Perceived Stress Scale (PSS-10) [9]. PSS is a 10-item questionnaire

that measures the degree to which situations in one's life are appraised as stressful.

### E. Social Robot Design Activities

Our data crossed several interaction design activities. In each setting, teens were invited to participate in at least one and sometimes 2-3 robot activities. Given the context of the school environment, some teens browsed or witnessed other activities after their assigned tasks were completed. Each activity involved direct interaction with a robot or robot prototype. The robots we used in these interactions ranged widely, with each type allowing for a specific type of interaction (Figure 2). EMAR V2 and V4 both allowed for verbal and touch screen interactions, whereas Blossom, a soft-bodied movement robot, allowed teens to experience operating and interacting with non-verbal interactions. Kuri, a commercial robot, provided mobility, allowed for interactions that included haptic responsiveness and sound (rather than speech) interactions. Finally, EMAR in virtual reality, allowed for an immersive, virtual interaction.

- *Activity 1: Observe & Feedback* – Participants are given a demonstration of an EMAR robot prototype and asked to provide feedback about their likes and dislikes related to certain prototype features such as the face, voice, or embodiment.
- *Activity 2: Interact & Feedback* – Participants naturally interact with an autonomous robot prototype on their own and then are asked about their likes and dislikes related to the robot. This involved different robots: (1) Kuri, a mobile robot that responds to detecting humans or sensing touch with facial expressions, purring, and movement. (2) EMAR V2, a wood-framed robot with LED eyes, child-like voice, and a touch screen for user input, which verbally asked participants about their stress level, mood, and energy level.
- *Activity 3: Operate, Interact, Observe* – Participants enacted or observed a teen-robot interaction in which the teen told the robot about a stressful event while the robot (operated by one of the participants) listened and responded. This activity involved two different robot prototypes: (1) EMAR V4 responded with speech and facial expressions and (2) Blossom responded with movement.
- *Activity 4: Robot design* – Participants collaborated in pairs in a custom virtual reality game to design a modular robot and later control/interact with the robot.

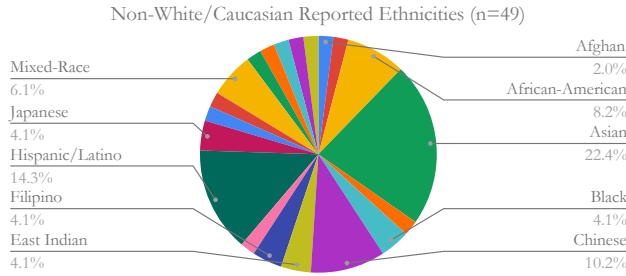


Fig. 3: Distribution of non-white participant ethnicities.

In another instance, participants used a slider interface to design a robot face for the EMAR V4 prototype.

- *Activity 5: Stress stories* – Participants created storyboards describing a stressful situation they have encountered and how a robot could help them cope with stress. Some participants also wrote down a script about something stressful they would like to share with a robot, which was used in Activity 3.

All interactions took place at a high school and included teens in small groups (2-5). Individual activities ranged in length from 3-15 minutes. Some teens were able to participate in 2 or 3 different activities. In all cases, teens were engaged in the activities, often expressing disappointment when their sessions were over.

#### F. Analysis

Survey data were captured on paper, entered in SPSS version 24 and then analyzed for normalcy and outliers. Both the PSS and the modified NARS scales were reverse coded where appropriate and scored, including the NARS emotional subscale. An ANOVA was conducted to explore any significant group differences across schools, grades, and ages. Descriptive analyses were run to determine average survey scores and items. A MANOVA was used to explore the effect of stress, age, and gender on NARS items. Finally, a two-tailed, paired t-test was conducted to explore differences in pre and post NARS items (prior to reverse scoring), subscales, and total scores for participants who had both pre and post surveys.

### V. RESULTS

We report on the results from our analysis. We first present descriptive statistics from the questionnaire taken before participants were exposed to robots in our studies. We then report changes in teens' attitudes resulting from robot interactions and design sessions.

#### A. Participant Demographics

One hundred and thirty-six (136) teen participants across five urban, Pacific Northwest high schools completed the questionnaires before participating in any of the robot design activities (pre). Participants ranged in ages 14-18 (M=16.16) and grades 9-12 (M=10.7). There were 44 females (32%), 87 males (64%), 4 Non-Binary (3%) and 1 who chose not

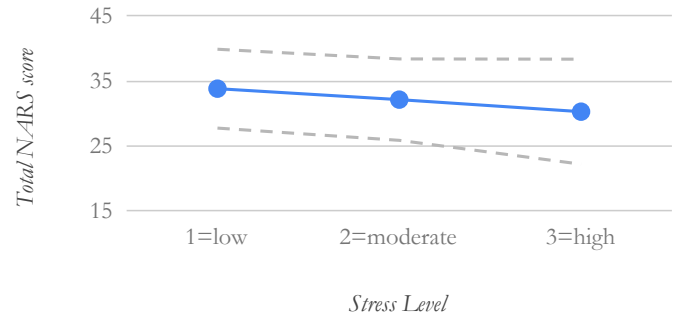


Fig. 4: Inverse relationship between teen stress levels and teen attitudes towards robots at baseline. Dashed lines indicate standard deviation.

TABLE I: Baseline Measurement of All Teen Attitudes (n=136) towards Robots

	Question	Mean	SD
Q1	NARS I would feel uneasy if robots really had emotions.	2.76	1.25
Q2	NARS I would feel relaxed talking with robots.	3.22	1.06
Q3	NARS If robots had emotions, I would be able to make friends with them.	3.07	1.21
Q4	NARS I feel comforted being with robots that have emotions.	2.64	1.02
<b>Q5</b>	<b>NARS I would feel very nervous just standing in front of a robot.</b>	<b>3.99</b>	1.10
Q6	NARS I would feel nervous talking with a robot in front of other people.	3.06	1.24
<b>Q7</b>	<b>NARS I would feel paranoid talking with a robot.</b>	<b>3.61</b>	1.15
Q8	I would trust a robot with my data.	2.72	1.09
Q9	I would feel comfortable sharing my emotional data with a robot.	2.91	1.18
<b>Q10</b>	<b>I think robots can help people.</b>	<b>4.34</b>	0.91

There were n= 136 teen participants who completed the attitude survey before participating in robot design activities. Items where most participants selected "Strongly Agree" are bolded.

to identify their gender. 86 participants (63%) identified as "White" or "Caucasian" with the remaining 49 (27%) describing other ethnicities (Fig. 3).

#### B. Baseline Perceived Stress and Teen Attitudes Towards Robots Survey

Compared with national norms [9], average teen stress levels were high with only 25% of teens (n=34) reporting a low level of stress, 64% of teens (n=87) reporting a moderate level of stress, and 8% of teens (n=11) reporting a high level of stress. Although not statistically significant, participants with a higher level of stress had lower scores on the NARS at baseline (Figure 4). No significant differences were found for age, grade, school, or gender related to the NARS scores.

Table I shows the average scores across the different items of the teen attitudes towards robots scale. Teens most strongly agreed with the positive item (Q10), "I think robots can help people" (M=4.34 (reverse coded), STD=.91) followed by their disagreement with a negative item (Q6), "I would feel very nervous just standing in front of a robot"

TABLE II: Comparison of Teen Attitudes towards Robots before and after Robot Design Participation.

	M (pre)	M (post)	SD (post-pre)	<i>t</i>	df	p
Q1	2.65	2.85	.2	-1.73	94	0.087
<b>Q2</b>	3.28	3.47	-0.19	-1.99	94	<b>0.049</b>
Q3	3.12	3.12	0	0	94	1
<b>Q4</b>	2.67	2.91	-0.232	-2.56	94	<b>0.012</b>
<b>Q5</b>	3.97	4.18	-0.21	-2.17	94	<b>0.032</b>
Q6	3.2	3.03	.168	1.16	94	0.25
Q7	3.65	3.62	.022	.212	92	0.832
Q8	2.67	2.69	-0.021	-0.19	93	0.843
Q9	2.84	3.01	-0.17	-1.61	93	0.11
<b>Q10</b>	4.34	4.54	-0.20	-2.07	94	<b>0.041</b>
<b>S3</b>	9.073	9.494	-0.421	-2.23	94	<b>0.028</b>
TOTAL	32.38	33.23	-.846	-1.89	90	0.062

There were  $n=90$  teen participants who completed the questionnaire before and after participating in a robot design activity. Bolded items represent statistically significant differences. Positive items (Q2-4, Q8-10) were reverse coded when calculating total NARS scores. Note that M (pre) is slightly different from numbers presented in Table I as numbers presented here are for the subset of participants who completed both pre-study and post-study questionnaires.

( $M=3.94$ ,  $STD=1.18$ ). In addition, they mostly agreed with the item (Q7) “I would feel paranoid talking with a robot” ( $M=3.61$ ,  $STD=1.15$ ). Responses to the rest of the items were closer to “Neither Agree or Disagree” for the teen sample.

### C. Impact of Teen Robot Interaction on Robot Attitudes

After participating in robot design activities, 90 teens completed the teen attitudes towards robots questionnaire again (post). Their total score had increased, meaning that overall teens had increased disagreement with the negative items on the scale, although not significantly. Table II shows comparison of pre and post measurements. Item 10, “I think robots can help people” still had the highest score of “Strongly Agree” by most participants ( $M=4.54$ ), and it showed a significant increase from the pre-study to post-study ( $p=0.04$ ).

A few of the other questionnaire items had a significant change as a result of exposure to robot design activities. Teens reported significantly increased agreement with item Q2 (feeling relaxed talking with a robot) and they reported significantly increased agreement with item Q4 (comfortable with a robot that had emotions). They showed increased disagreement with item Q5 (nervous standing in front of a robot). We also found a significant increase in the aggregate NARS Emotional Subscale as a result of the robot interaction activities.

Other items had no significant change. For example, agreeing they would be able to make friends with robots (Q3), disagreeing with feeling paranoid about talking with a robot (Q7), and mild agreement about trusting a robot with their data had no significant change as a result of robot design activities.

## VI. DISCUSSION

### A. Implications for Design

Key findings from our exploration of teens’ attitudes towards robots, as well as the effect of robot interactions and design sessions, presents three distinct implications for the design of a social robot for teenagers as part of Project EMAR as well as other projects.

First, these data help to confirm that studies on adult attitudes may not be directly transferable to teens. Recognizing teens as distinct from adults as a result of their developmental phase has been previously suggested [15], however, teens are also likely different from adults in their digital literacy. Many of today’s teens began using digital technology at birth [12] and therefore, have quite a different relationship with technology than many adults. This digital literacy likely impacts their views and interactions with social technologies and robots as well. Supporting differences between teens and adults, we found no significant gender difference in attitudes towards robots before or after the social robot interactions and design sessions. Previous studies of adult attitudes propose gender as a prominent moderator of attitudes towards robots. In the 2014 Stafford study involving older adults [36], after evaluating a robot’s virtual face, men’s attitudes towards the robots were increased compared to those of women. In a study on older adults, [21] found male attitudes towards healthcare robots were more positive than females. These studies suggest that the gender may affect robot attitudes in adults, but perhaps that effect does not translate to the teen population.

Second, overall teens embraced the idea of talking with and even being emotional with a robot. In addition, as evidenced by the significantly positive change in the emotional subscale of the NARS, their emotional attitudes increased as a result of robot design and interaction sessions. These findings support the notion that if designed appropriately, social robots may be an engaging and appropriate tool for emotional engagement with adolescents. In addition, interactions with social robots may improve attitudes and reduce concerns about social robots intended to support mental health.

Third, one prominent attitude that was stable across teens and even across interactions, was the teens’ lack of trust regarding their data. Trust is a well established concept in HRI [16]. It has even been purported that without trust, bonds between humans and robots cannot be formed [43]. In our case, we captured an item specific to trusting the device with their data. We have already learned from teens that they prefer our robot not be networked to protect their privacy and protect their data from hacking. Many of today’s teens are aware of the potential downsides of technologies having experienced cyberbullying [20] and digital hacking [22]. So this particularly stable attitude suggests that despite positive emotional attitudes, and even engaging robot interactions and design activities, teens maintain a healthy skepticism about how their data and technologies can potentially be misused. Trusting a device with their data and trusting the device itself, however, needs to be delineated and explored further.

Therefore an imperative next step is to explore the larger concept of trust in HRI with teens.

Our study present preliminary findings regarding teen's attitudes about robots, as well as how their beliefs and attitudes change as a result of a range of robot interactions. These findings provide insights that directly inform the design of social robots for teens. In addition, our findings suggest that significant changes in attitudes are quite likely for teens who have interacted with a robotic device, therefore confirming the importance of conducting studies with physically embodied devices in the wild to maintain contextual validity and capture valid data.

### B. Limitations and Future Research

The unstructured, in-the-wild format of our studies offered a great context for our design activities; however, also limited the amount of control we had. As we were unable to track what activities were performed by which teenager participants, we could not analyze whether certain types of interactions resulted in specific changes in relation to attitude. In most cases, all participants had exposure to all activities that were taking place in their classroom, even if they did not directly take part in the activity, through instructions given by the research team and observations of their peers performing the activities. The question of which attitudes may remain stable in teens over time and across different ways of getting exposed to robots, deserves further exploration.

In addition, due to limited time of our teenager participants, we were unable to ask open-ended questions (e.g. "why?") questions to explain different attitude questionnaire answers) that would provide more qualitative data to better understand the reasons behind our quantitative findings reported in this paper. We also were curious to begin exploring participants' sense of trust regarding sharing information with a robot, however we will need a much more controlled study to actually test how trust changes as a result of robot interaction. Our future work will explore such concepts further.

## VII. CONCLUSION

Even while teenagers are the next generation likely to live, work, and interact daily with social robots and autonomous devices, there is limited teen-robot-interaction research. Our own past explorations with teen-centered robot interaction design has revealed the unique perspectives this population has about social robots. This motivated us towards establishing the general teen attitudes towards social robots. In this paper we present findings from measurements of 90 teenagers' attitudes towards robots before and after some form of exposure to robots at their school.

These initial data regarding teens' attitudes towards robots as well as our study of the effect of robot interactions and design activities on those attitudes presents the very beginning of truly understanding teen-robot interaction. Teens' stable beliefs that robots can be helpers and their positive emotional attitudes towards robots are encouraging for our

own project and others hoping to leverage social robots as a technology to improve teen mental health. In addition, these data further validate the theory that teens are not adults or children, but rather a unique population that deserves further research especially if we hope to design appropriate and effective robots to improve their health.

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